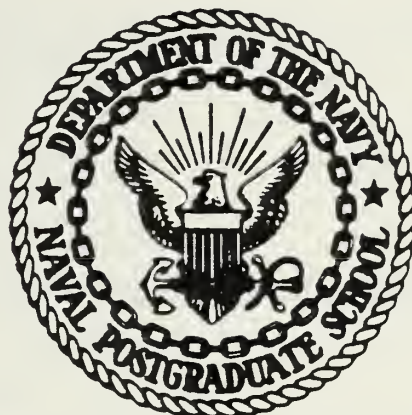


TEST AND EVALUATION AND GRADUATE
EDUCATION NEEDS

Cornelius Neil Jubeck

NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

TEST AND EVALUATION AND
GRADUATE EDUCATION NEEDS

by

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June 1981

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Block 20 continued

The evolution of DOD T&E is traced and analysed with particular attention to capability requirements of personnel.

The general conclusion is reached that the hypothesis can not now be universally supported. Reasons for this position are given and recommendations made for improving capabilities of T&E personnel.

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Test and Evaluation and
Graduate Education Needs

by

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ABSTRACT

The hypothesis is advanced that testing and evaluation (T&E) of complex weapons systems requires unique skills, that the testing and evaluation of weapons systems has evolved into a recognizable engineering discipline, and that professional technical personnel in the Department of Defense Test and Evaluation community should be considered as unique assets and supported by the establishment of a postgraduate curriculum in T&E engineering.

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I. INTRODUCTION

A. GENERAL

Test and Evaluation (T&E) is conducted to support the acquisition of weapon systems by the Department of Defense (DOD). These weapon systems integrate the latest advances in technology and are complex. T&E field activity personnel have suggested that advanced education is required to support the T&E of modern weapon systems. It is also believed that T&E is evolving as an engineering discipline, and a graduate level curriculum in T&E engineering should be established.

B. OBJECTIVES

The objectives of this study are to:

1. Show that T&E is an important element of the weapon systems acquisition cycle and should be recognized as a discipline which is unique to DOD.

2. Determine if there is a need for T&E postgraduate education and if it should be institutionalized in the DOD.

3. Propose a model for T&E postgraduate education for military and civilian personnel.

C. HYPOTHESIS

The T&E of complex weapon systems and sub-systems requires unique skills to understand, design, conduct, evaluate, and report test results. The T&E of weapon systems in support of

the DOD acquisition cycle has evolved into a recognizable engineering discipline. The professional technical personnel in the DOD T&E community should be considered as unique assets and should be supported by establishing a postgraduate curriculum in T&E engineering.

D. SCOPE

This research considered the evolution of T&E in the DOD in the 1970's to the beginning of the 1980's. The T&E of aircraft weapon systems in the Department of the Navy (DON) was used as the primary means for illustrating the objectives of this research. If a continuum of need (from minimum to maximum) for T&E postgraduate education was applicable, the T&E of aircraft weapon systems would fall in the maximum need position of this scale. This constraint does not detract from the universality of the results to the role of T&E in support of other types of weapon systems acquisition in the DOD. Although each of the Services does not face exactly the same conditions in acquisitions of weapons systems, the tasks and problems of T&E are similar. Departments of the Army and the Air Force T&E perspectives were used when appropriate to this study.

E. METHODOLOGY

The approach used to prepare this study was threefold. The author relied heavily on 15 years of experience in the T&E of aircraft weapon systems. An archival search was conducted for references relative to this study. Interviews

were held with Naval Postgraduate School faculty, high level DOD officials, and T&E field activity personnel.

F. REVIEW OF RELATED LITERATURE

Two previous Naval Postgraduate School (NPS) theses [Refs. 1,2] deal with the T&E of Navy aircraft weapon systems and are related to this study topic.

In reference 1, LCDR Bowes evaluated the Navy T&E process for aircraft weapon systems, identified deficiencies and good features of this process, and proposed a reorganization of the Navy's T&E organizational structure. One of his conclusions was the need for a course of instruction in the discipline of weapon system T&E. In addition he recommended that a Systems T&E Training School should be established at each of the major test centers resulting from reorganization of the Navy's T&E activities. This thesis presents the first documented need for formal Navy T&E education.

In reference 2, LCDR Stoll examined the tasks assigned to, the level of knowledge and experience of, and the need for formal education of project officers at aviation T&E activities. He proposed a T&E education syllabus and alternatives for achieving it based on the results of a survey of 78 project officers located at development and operational aviation T&E activities. Seventy-three officers were then attached to the test activities and five were attending NPS but had previous T&E experience.

He reviewed test reports from the test activities to determine the areas of knowledge and compared these with areas of knowledge obtained from interviews and questionnaires. Three out of four officers had received inadequate or no formal training in the pertinent subject areas. One out of two project officers, in their first year of experience, indicated that their lack of T&E knowledge reduced their effectiveness to do their jobs. As a result of the interviews and questionnaires, the pertinent subject areas were reduced from 61 to 49. These results substantiated the need for formal T&E education.

LCDR Stoll designed a syllabus consisting of 10 courses and 110 instructor contact hours. Six alternatives were proposed. The alternatives range from a four to six quarter in-residence T&E curriculum at the NPS (least favored by the project officers, since they would rather be flying) to local programs conducted by the test activities. He concluded that one approach would not satisfy the need for formal T&E education, consequently, a combination of methods was the recommended approach. An idealized approach was presented which considered eventual implementation of all the proposed alternatives as a solution to this dilemma.

Since these theses were completed, the Naval Air Test Center was reorganized and the Naval Air Systems Command established an AIR-06 T&E Coordinator Division. It's mission is to coordinate and manage the Naval Air Systems Command

T&E resources which include the field activities and the major test ranges. In addition, the T&E Coordinator integrates the operational T&E command test requirements into the Test and Evaluation Master Plan for aircraft weapon systems. The theses do not address the education requirements of the civilian T&E population which is a major portion of the T&E community.

Reference 3 is related in several ways to this study. Dr. Matthews provides a compilation of T&E related material which he prepared to focus attention on the evolving nature of T&E. He advocates the recognition of T&E as an engineering discipline. From his viewpoint T&E in the DOD is an extension of basic scientific and engineering disciplines. One of his observations was that there is a need for formal T&E education and he proposed several alternatives for implementing it. The emphasis of this document is toward providing a reference source for background information on T&E in the DOD and an aid to promoting T&E as an engineering discipline.

G. DEFINITIONS

Each of the Services over the years has introduced terminology pertaining specifically to its efforts in T&E. The Joint Logistics Commanders (consists of Commander U. S. Army Materiel Development and Readiness Command, Commander Air Force Logistics Command, Commander Air Force Systems Command, and Chief of Naval Material Command) was formed to promote

cooperation in joint service acquisition programs. An ad hoc group on T&E planning guidance published the Compendium of Test Terminology [Ref. 4]. This document provides a useful working level reference to avoid confusion when the same term is used by each Service. The following definitions define the three types of T&E most frequently referred to and defined in reference 5.

1. Development Test and Evaluation (DT&E)

DT&E is that T&E conducted to assist the engineering design and development process and to verify attainment of technical performance specifications and objectives. DT&E is usually accomplished or managed by the DOD Component's material agency. It includes T&E components, subsystems, hardware/software integration, related software, and prototype or full-scale engineering development models of the system. T&E of compatibility and interoperability with existing or planned equipment and systems are also included.

2. Operational Test and Evaluation (OT&E)

OT&E is that T&E conducted to estimate a system's operational effectiveness and operational suitability, identify needed modifications, and provide information on tactics, doctrine, organization, and personnel requirements. Acquisition programs shall be structured so that OT&E begins as early as possible in the development cycle. Initial Operational Test and Evaluation (IOT&E) must be accomplished prior to the Milestone III decision (production).

3. Production Acceptance Test and Evaluation (PAT&E)

PAT&E is T&E of production items to demonstrate that procured items fulfill the requirements and specifications of the procuring contract or agreements. Each DOD Component is responsible for accomplishing PAT&E.

II. BACKGROUND

A. GENERAL

The weapon system acquisition policies of the DOD in the late 1960's received a lot of public attention. DOD had earned a reputation for cost growth, schedule delays, and production of systems before they were ready. This increased visibility of DOD's perceived mismanagement of the defense tax dollar resulted in a study of the entire organization, structure and operation of DOD [Ref. 6]. A part of this study was a review of the role of Test and Evaluation (T&E) in the acquisition of weapon systems. A conclusion of the study was:

"Operational test and evaluation has been too infrequent, poorly designed and executed, and generally inadequate."
[Ref. 6:2]

To focus additional attention on test and evaluation the study recommended a Defense Test Agency which would oversee all Defense T&E. Specifically it would design or review the designs for tests; monitor the entire Defense test program; and conduct T&E of systems which can be used across Services. Also, the Panel recommended that a separate funding category should be identified for T&E and operational testing. The Defense Test Agency would have responsibility for this funding.

Deputy Secretary of Defense, David Packard, was instrumental in implementing recommendations of the Blue Ribbon

Defense Panel which have affected T&E. He established the Director of Defense T&E and moved the Services to establish independent test agencies which report to the Service Chiefs [Ref. 7]. Additionally, he increased the role of OT&E results in the acquisition process by issuing DOD Directive 5000.1 [Ref. 8] requiring that OT&E be conducted before a decision is made on full scale production. Congress also gave momentum to the changing role of OT&E by passing a law which requires that DOD give Congress, annually, the results of OT&E with its request for funds on systems it is planning to procure [Ref. 9]. The DOD Directive 5000.3, Test and Evaluation [Ref. 7], was issued to define policy on the types of testing and the roles of the Services in T&E. This directive also established the requirement for a Test and Evaluation Master Plan (TEMP) which coordinates all the testing requirements for a given program.

The Defense Science Board Task Force on T&E was formed in late 1972. It was tasked to study a group of major weapon systems to determine whether improvement in T&E would permit earlier discovery of problems and initiation of corrective actions. Its report [Ref. 10] in early 1974 identified that improvements were needed in test planning and scheduling. T&E participation was frequently deleted due to overruns of time and money in other phases of the program. The Panel described a T&E gap which occurred when testing pre-production hardware or prototypes. Since the decision to start production cannot

occur until after initial OT&E (IOT&E) is completed, a substantial lag (1.5 to 2 years) exists between completion of development testing and manufacture of the first production article. The Panel also provided nine related reports which provide T&E guidelines for different types of systems, for example, for missile weapon systems and for aircraft systems.

The Office of Management and Budget published OMB Circular A-109 in 1976 which outlined the government's policy on the acquisition of major systems [Ref. 11]. This circular was issued to curb cost overruns and ensure the new systems are needed. As a result of the issuance of this circular the DOD and Service directives and instructions had to be revised. No major changes in T&E policy were generated except for the reemphasis of the requirement for T&E criteria. This included the concept of independent testing and testing in the operational environment prior to approval for full production.

The lengthening of the acquisition cycle was studied by a Task Force of the Defense Science Board and reported in 1978 [Ref. 12]. It concluded that sequential and separate testing of the systems by the test activities of the developer and the independent test activities representing the user often adds unnecessary costs and time. Thus the Task Force recommended conducting combined development and operational tests wherever feasible and separate evaluations of the data. The Task Force expressed concern that independent test activities with their

increased influence would demand duplicate facilities and increased testing. What is really desireable is combined within the same service) testing and independent evaluation. Also, it was felt that the T&E activities should participate throughout the entire acquisition cycle.

B. ENVIRONMENT

Presently, two major Navy aircraft weapon systems are in full scale development testing at the Naval Air Test Center, Patuxent River, Maryland. The F-18 program is employing the single-site test concept. The contractor performs its development and operational testing at this government facility with Navy test activities monitoring the contractor's tests. At specified times each of the Navy's test activities conduct testing and perform independent evaluations of the data. This approach has numerous advantages and disadvantages which have not been fully assessed.

The second major aircraft weapon system in full scale development testing at the Naval Air Test Center is the Light Airborne Multi-Purpose System (LAMPS) MK-III. The LAMPS MK-III helicopter and airborne systems are an extension of the ship's Anti-Submarine Warfare (ASW) capability. In the case of the LAMPS MK-III the Naval Air Test Center is not a single site test location. It functions as the focal point for all the Navy field activities' participation in the testing of the complete LAMPS MK-III weapon system (includes aircraft and

ship systems). The responsible operational test activity is participating in combined testing with the developer's test activities to reduce duplication, time, and costs of testing. The operational test activity still retains designated test periods for Initial OT&E (IOT&E) and Follow-on OT&E (FOT&E). The Test and Evaluation Master Plan (TEMP) was utilized as a major management tool in working out the participation of the T&E activities in this program. The flow of instructions which govern the preparation of the TEMP is shown in Appendix A, Figure 1.

The T&E participation in the minor acquisition programs normally does not fare very well. It is estimated that minor acquisition programs amount to three times the major programs. The management, however, of these programs is not normally provided with sufficient resources or experience to manage the acquisition until it runs into trouble. The Services have initiated the same acquisition procedures for minor programs as for major programs with lower level review and approval requirements. Consequently, the preparation of a TEMP to coordinate the T&E effort is an exception rather than a rule. Few, if any program management offices, have personnel experienced in T&E. The TEMP is a useful test coordinating document, because, it brings the players together to negotiate their requirements. It must be remembered, however, that the acquisition cycle is dynamic, and the TEMP is a point-in-time document. The program office must therefore

become innovative in its effort to communicate changes in the TEMP to all the participating activities.

C. TECHNOLOGY

The major and minor acquisition programs normally incorporate the latest technological advances. American industry is the world leader in developing new technology and in bringing it to the market place. High technology is driving the economy while all segments of industry scramble to apply it to increase productivity and drive down production costs. This same psychology exists in the acquisition of weapon systems.

The T&E community personnel are dealing with increasingly sophisticated and complex equipment and systems. The use of airborne computers and associated software have found application in on-board processing of information and analysis of acoustical data in ASW missions, navigation, weapons delivery control, communication, etc.. Rapid advances in semi-conductor devices continues at a rapid rate. Functions which previously could not be accomplished because of the size of the resulting hardware are now being incorporated into airborne platforms. Flight-control systems are now built around airborne computers vice mechanical linkages. How the aircraft flies is a function of the application of complex mathematical control theory and programming skills.

Airborne Command, Control, Communication and Intelligence (C³I) functions are performed airborne as well as on the ground. Achievement in this area has leaped forward with the incorporation of semi-conductor advances into airborne radar and communications devices. Likewise the electronic warfare capabilities to detect, jam, or fool the aggressor have all been enhanced by the incorporation of semi-conductor technology.

Material technological advances in ceramics, composite and metal compounds are being used in airframes to increase strength to-weight-ratios, reduce detectability, and to increase reliability and maintainability. Technological advances in ceramics and metal compounds, producing higher temperature resistant materials, are being applied to propulsive devices. As a result, jet engines are producing higher thrust-to-weight ratios and are more energy efficient.

The technology list that the T&E community must deal with is lengthy. The T&E of these high-technology systems presents unique testing challenges. The challenge facing the T&E community is to stay technically competent to do effective testing in the face of fixed personnel ceilings and increasing workload.

D. ORGANIZATION STRUCTURE

The Secretary of Defense (SOD) established the Director of Defense for Test and Evaluation (DDT&E). The DDT&E was designated to report through the Under Secretary of Defense

for Research and Engineering. The DDT&E was identified as having responsibility for monitoring and advising the SOD on T&E conducted by the Services. It also provides access to the office of the SOD for the Services' OT&E activities on matters concerning independent testing. It is unlikely that the military OT&E activities would use this access without going through their normal command structures first. The DDT&E organizationally is also the focal point for joint service testing programs.

The organizational changes which resulted from the increased emphasis on OT&E had the least impact on the Navy. The Navy already had the Operational Test and Evaluation Force (OPTEVFOR) in being. Therefore, it was able to comply rapidly to Deputy Secretary of Defense Packard's request for the Services to set-up independent operational testing agencies. The Navy established a Director of RDT&E, OP-98, with the Commander of OPTEVFOR, OP-983, reporting to the Navy Director of RDT&E. This organizational change was the Navy's compliance for the operational test activity to report to the Service Chief independently of the developing agency.

The Naval Air Systems Command organizational structure was amended in 1975. An Assistant Commander for Test and Evaluation Coordination was established [Ref. 13]. This organization had existed previously at a lower organizational level and was tasked with allocating the Navy's RDT&E aircraft resources. This organizational change was partially attributed to the

findings of the Donaldson Committee Report on the T&E base study, conducted for the Commander Naval Air Systems Command [Ref. 14]. A similar type of organization for T&E coordination is not used by the other Services.

The Army and the Air Force required several years, until the mid 1970's to comply. The Army established the Operational Test and Evaluation Agency (OTEA) and the Air Force set up the Air Force Test and Evaluation Center (AFTEC). The Commander of OTEA reports to the Army Chief of Staff and the Commander of AFTEC reports to the Chief of Staff Air Force. Both OTEA and AFTEC have small headquarters' staffs which are dependent on the operating commands to provide the manpower resources to support OT&E. The Army and Air Force started out emphasizing combined testing in order to reduce costs and to use pre-production resources more efficiently.

E. PLAYERS

1. Program Manager

The program manager is the hub of the acquisition cycle and the key to the level of T&E participation. He must budget and plan for this participation and provide for any special resources such as facilities which could involve military construction funding. Normally the program manager changes many times during major weapon system acquisitions. Since it takes from 12 to 15 years from concept initiation to initial operational capability, it is not unusual for a program to have five program managers.

The program managers seldom have previous T&E experience and it is easy for an adversary relationship to develop between the program manager and the test community. He frequently does not understand the functions of the Major Ranges or the Test Centers and how to use them to support the development effort or reduce engineering risk. The test activities by reporting what is wrong with the system increase the program office workload to explain away the problems or to plan for funding and schedule changes to correct the deficiencies.

The military specifications and policy instructions which are part of most weapon system contracts have built-in test requirements which often come as a surprise to the inexperienced program manager. Viewing T&E from the program manager's perspective, his main objective is to get the OT&E activity to grant a Provisional Acceptance for Service Use (PASU) or an Acceptance for Service (ASU) which is the more desirable. In the real world of politics, funding availability, and schedule crunches the tendency is to make decisions favoring OT&E requirements at the expense of DT&E requirements.

Program managers for minor programs are normally even less prepared than the managers of major programs. Even though the minor programs account for approximately three times the funding of major acquisition programs, the program manager is frequently a technical type who has not developed the management and technical competencies to conduct a minor acquisition. He must write the technical requirement portion

of the Request for Proposal, evaluate proposals, write the work statement, provide technical direction to the development effort, write test requirements, plan the conduct of the engineering development tests, and provide guidance to higher management. The minor program manager historically is competing with the major programs for funds inadequate to support the procurement of all the items in development. Testing appears as an expensive item in a limited funding situation or in an inadequately planned program and is usually among the first items to be compromised. Minor programs, due to lower visibility, are even more susceptible to frequent program manager turnover. One of the findings of a GAO report conducted on the Defense System Acquisition Review Council (DSARC) was a relatively rapid turnover of high ranking DOD and Service personnel responsible for the integrity of the DSARC process [Ref. 15]. High ranking DOD civilians and military personnel were changed at an average of 28 months and 24 months respectively. This data certainly reflects unfavorably on the management of the acquisition cycle and is relatively representative of program manager turnover. Unless the T&E program is documented in a TEMP in the early phases of the acquisition cycle, T&E is always vulnerable to inadequate funding and support.

2. DT&E Testers

The contractor for the weapon system conducts testing during the acquisition to support engineering development

efforts. The government personnel employed by the Major Ranges and Test Facility Base (MRTFB) are primarily responsible for conducting the government's technical testing during the full scale development and production phases of the acquisition cycle (Appendix A, Figure 2). The developer's test activities also participate in the earlier phases of the acquisition cycle but at a lesser degree than laboratory or development center personnel. A listing of MRTFB and other activities involved in T&E are listed in Appendix A.

It is difficult to determine the exact number of government personnel employed in T&E. The civilian ceilings have declined some in recent years, however, with an increasing work load the test activities have turned to contracting to operate test ranges and for some engineering support. Collectively the DOD RDT&E community totals in excess of 100,000 personnel [Ref. 16]. The DDT&E estimates that approximately 50,000 military, civilian, and contracted for personnel operate the MRTFB and provide special test support. These figures do not include OT&E personnel such as those assigned to COMOPTEVFOR and the operating forces assigned temporarily to the Army and Air Force operational test activities.

The MRTFB is staffed with both military and civilian engineers and scientists. It is estimated that they will spend \$1.1 billion in FY 1981 [Ref. 17] not including the use of Operating and Maintenance (O&M) funds -- O&M funds support the weapon system once it is in production to the end of its

life cycle -- to conduct T&E of weapon systems. In terms of government personnel and funds T&E is big business.

The DT&E community in the past has had difficulty in obtaining engineering and scientific personnel due to a combination of factors. A declining number of graduates in engineering and the sciences, remote locations of the DT&E activities, reduced personnel ceilings, hiring freezes which frustrate recruiting efforts, and starting salaries substantially below industry entry levels have summed to weaken the DT&E technical base. Military personnel, specifically Navy, with previous T&E experience are less likely to return for a second tour of the DT&E activities due to a lack of a defined career path in T&E. This is especially true in the DT&E of Navy aircraft weapon systems. Costly and extensive training is provided to naval flight officers to develop engineering test pilot skills. In turn these officers serve an approximately two-year tour before moving on to an assignment unrelated to their T&E skills.

DT&E skills are mostly learned by on-the-job training (OJT). Each of the DT&E activities have established the methodologies and techniques, instrumentation, and facilities to acquire hard data to make assessments of engineering development and risk. Most of the DT&E activities are in remote areas and are limited markets for advanced technical education. This has constrained the access of the DT&E personnel to

advanced technical education needed to renew their engineering skills to challenge the complexity of modern weapon systems.

The Navy DT&E of aircraft weapon systems uses skilled military operator personnel. Even though DT&E is conducted under more controlled conditions than operational testing, military test personnel are qualified to relate test results to expected performance under fleet operating conditions. The DT&E results are reported to the development agency and OT&E personnel are encouraged to use DT&E results where feasible. Also, DT&E personnel are required to support OT&E. In contrast OT&E results are reported to the Chief of Naval Operations level and are not normally available to DT&E personnel. The reporting of weapon system deficiencies by DT&E personnel are not necessarily reported in the same form as by OT&E personnel.

3. OT&E Testers

T&E is a team effort consisting of the program manager, the development test activities and the operational test agencies. Most of the focus, however, in the 1970's has been on an increase of the role of operational testing. The acquisition policy has been changed to include participation of OT&E personnel throughout the acquisition cycle. The Services have used different approaches to meet the increased responsibilities of OT&E. The Navy has its operational test agency headquarters in Norfolk, Virginia. It has staffs on the East and West Coast, three operational aircraft squadrons (based on type of aircraft and mission), and detachments --

as required to support new tactics, operating procedures, and techniques. The Army's operational test agency is located at Falls Church, Virginia and the Air Force operational test center is located at Kirtland Air Force Base, New Mexico. The Air Force and Army staffs are small in comparison with the Navy (less than 100 personnel vice more than 1400 for the Navy). None of the Service OT&E agencies employ many civilians, therefore, continuity in the lengthy acquisition cycle is difficult to maintain unless military reassignments are made less frequently. The Navy does not provide for extended tours for military personnel assigned to OPTEVFOR. In fact this would be contrary to the policy stated by COMOPTEVFOR [Ref. 18]. This memo expresses the importance of having skilled operators with recent "blue water" experience vice highly trained technical operators to conduct operational testing. The Navy OT&E concept was used by the Blue Ribbon Panel as an example for the other Services to consider. The Navy OT&E was faulted for its inability to produce "hard numbers" to assist high level decision making. The COMOPTEVFOR has employed a few civilian analysts to improve on this situation.

The GAO in 1977 began a review of the Service OT&E efforts. The Navy, having the most experience with an OT&E organization, was reviewed first [Ref. 19]. GAO found the Navy was still making production decisions with incomplete OT&E results. OT&E could not be conducted on some systems due to a lack of test resources, and OT&E conducted on systems,

after production approval was granted, found performance problems that should have been corrected before production approval.

OT&E agencies feel they are the only test activities which test the complete weapon system. OPTEVFOR views are expressed on this position in the Operational Test Director Guide [Ref. 20]. This manual also raises an interesting point on the OPTEVFOR philosophy on the availability of operational test data:

"In some programs it may be convenient (or absolutely necessary) to use DA field agencies to get OT&E data reduced and, to some degree, analyzed. In these situations it is mandatory that these people be under the operational control of COMOPTEVFOR (represented by the OTC/OTD/Program Analyst) while they are working on OT&E data. Their work is defined in advance, and their results are furnished only to COMOPTEVFOR, unless COMOPTEVFOR has specifically approved a wider distribution." [Ref. 20: 16-2)

Field agencies are required to provide all information to OT&E personnel and it could be implied from the above that the exchange of data is in one direction only.

Although COMOPTEVFOR's earlier position was to shun the use of operator personnel with technical backgrounds, the extreme pressures to make production decisions using "hard data" has weakened this position. In the OT&E of aircraft weapon systems there is trend toward OPTEVFOR project personnel having technical backgrounds. This has the potential to change the OT&E viewpoint toward acquiring more hard data to substantiate OT&E results; and it raises issues on duplication between OT&E and the developing agency's test activities.

The Air Force and the Army have approached OT&E differently than the Navy. They have emphasized combined test activities of the developmental and operational testers, the sharing of limited pre-production resources, and the use of highly skilled operational testers. The GAO has criticized their policies on OT&E [Refs. 21,22]. In particular, both Services needed to conduct operational testing in environments more representative of the operational environment. Also, the Services should designate distinct periods for operational testing and provide the necessary test resources. The test personnel and support should be more representative of the type used when the system is deployed.

4. Board of Inspection and Survey and AIR-06

Two agencies which are unique to the Navy are the Board of Inspection and Survey (BIS) and the Naval Air Systems Command (AIR-06), the Assistant Commander for Test and Evaluation. The President of BIS is located in Washington, D. C. and has Sub-Boards of Inspection and Survey located in Virginia, California, and Maryland. The Sub-BIS for aircraft is located at Patuxent River, Maryland. It tasks, for example, the Naval Air Test Center to conduct technical tests of production aircraft weapon systems or follow on tests on significant changes to aircraft in use. Based on the test results the President of BIS recommends to the Secretary of the Navy whether the aircraft weapon system should be accepted for fleet use. The potential conflict or duplication of the BIS and

COMOPTEVFOR roles have been actively discussed and analyzed recently. The Navy expressed confirmation of the need for each organizations' function, role and contribution to the T&E process through the recent revision of OPNAVINST 3960.10A [Ref. 23].

The AIR-06 organization evolved from the need to provide a focal point for NAVAIRSYSCOM RDT&E resources. AIR-06 coordinates the Navy's Major Range and Test Facility Base (MRFTB) with DDT&E. Since the TEMP has become a key document for major weapon systems, AIR-06 has taken responsibility for coordinating the DT&E and OT&E requirements for the program manager. AIR-06 also coordinates the workload going to the NAVAIR field activities with the resources required to conduct DT&E. The effectiveness of this organization in performing its mission has not been confirmed since its establishment in 1975.

F. EVOLUTION

There is presently a significant variance between the Navy approach to T&E and those of the Air Force and Army. In the 1970's the decision making processes for major acquisition of weapon systems has varied from decentralization to the Services and then a return to centralization at the Office of the Secretary of Defense. Presently, the trend is toward accountability and decentralization to the Services as outlined in a recent Deputy Secretary of Defense memo [Ref. 24]. Consequently,

high visibility issues, such as, productivity improvement by increasing DOD effectiveness and efficiency through reduction in duplication of Service efforts will require more cooperation between the Services and more joint Service acquisition programs. This will magnify the differences in the Services' approaches to T&E and result in a buildup of forces toward more continuity in test techniques, methodologies, test personnel qualifications, and analytical techniques. The pressure by DOD for hard operational test data will increase. This will force the Navy to make substantial compromises in its past policies on independent operational testing and its need for more analysis in the evaluation phase. The Services will approach a common T&E base to allow DOD to make rapid management decisions to reduce the length of the acquisition cycle. DDT&E's future role is unclear in the present move toward decentralization. Since at present DDT&E operates primarily in a persuasive mode with the Services, increased joint Service programs might necessitate more authority for the DDT&E. A Defense Test Agency could even result [Refs. 6,16].

III. GRADUATE EDUCATION

A. GENERAL

The need for full-time, fully-funded graduate education for DOD personnel has received considerable attention in the 1970's. The declining enrollments in higher education has accelerated the availability of graduate education at DOD facilities as colleges and universities have competed for this source of revenues. Advances in technology and society's acceptance of the value of education has increased this need for continuing education by the work force. Most who seek advanced education do so to receive a graduate degree. Military positions have been established requiring advanced degrees to perform the duties of the job. This frequently has been done to enhance retention, increase the morale of the personnel and provide for increased job opportunities after retirement. On the civilian side, the bureacracy has used advanced degrees as a screening mechanism in selection for promotion and to increase the technical status of the organization.

Before most personnel make a commitment to long term training one of their chief concerns is whether the award of a graduate degree can be achieved. Since advanced degrees are becoming a norm in our society, it is unlikely there will be many participants in a full-time advanced education program

just for the benefit of the additional training. The selection of civilians for long-term fully-funded training, as a recognition for having high-potential to be future high-level leaders within DOD, places additional pressure on the recipient to earn an advanced degree. The sponsoring activities also subtly encourage that the advanced degree is an expected result of the trainee's efforts. The T&E activities, primarily those involved in development testing and evaluation, have long recognized and voiced the need for graduate education in support of the T&E process. The engineering schools have been reluctant to offer off-campus programs which lead to advanced degrees mainly for traditional and quality of graduate education reasons. Most T&E activities are in remote locations and provide a small market. This does not motivate the engineering schools to be flexible in their attitudes toward serving the needs of the T&E community. An MIT study found there was little research available to evaluate the performance of engineering schools in meeting the education needs of their graduates [Ref. 25]. Most engineering schools have been too preoccupied with spending Federal research dollars or graduating students to meet industry's requirements. They have consequently failed to solicit graduate feedback. The Accrediting Board for Engineering and Technology, in order to prevent stagnation in engineering education, does not advocate rigid standards for accreditation and encourages well-planned curriculum experimentation [Ref. 26].

The literature reviews cited in the Introduction proposed programs for graduate education in T&E. The Pacific Missile Test Center, a Navy T&E field activity, located at Point Mugu, California has also proposed some innovative programs to provide graduate education to its technical employees. The Naval Postgraduate School (NPS) in Monterey, California has two courses listed in its catalog which are titled Test and Evaluation which are taught by the Operations Research Department. In the past, informal discussions with Navy field activities' personnel have resulted in NPS spokesmen proposing "strawmen" T&E curricula. These proposals have not moved forward due to lack of Department of the Navy support and current constraints on NPS resources. The Naval Aviation Executive Institute Program was established at Naval Missile Test Center, Point Mugu, California in 1975 and moved to the NPS in 1976. This program has high potential to respond to the graduate education needs of the Navy's T&E community and could provide a model for the rest of the T&E community.

Some observations are presented on the status of T&E engineering as a profession. The parameters which have been identified that pertain to T&E of aircraft weapon systems but are relevant to the T&E of other weapon systems and equipment are discussed. The needs of different levels of personnel in the Navy T&E community are reviewed and a framework presented which could support T&E educational needs.

B. FULL-TIME, FULLY-FUNDED

The atmosphere for full-time, fully-funded graduate education in the DOD has not been very favorable. The NPS which in the early 1970's had an enrollment of 1200 Navy students has had its budget cut by Congress to where the NPS had 400 students in FY 1977. This figure has increased to 600 Navy students for FY 81 and the Congressional committees are in support of this level. The Navy and Air Force have been critized for the cost per student to provide postgraduate education for their personnel compared with the cost per student of using non-military institutions. The Navy has been the smallest user of public sector colleges and universities to provide full-time, fully-funded education. The Air Force, although it supports the Air Force Institute of Technology (AFIT), sends a majority of its full time graduate students to the public sector institutions. The Army sends most of its full time students to the public sector institutions except for those it sends to NPS and AFIT.

The GAO [Ref. 27] addressed the permissive attitude of the services toward full-time, fully-funded graduate education for officers. The services were tasked to validate positions requiring advanced education in order to perform the duties of the position. These were primarily positions in the science and technology areas. The intent of providing the postgraduate education was to prepare officers to function more effectively in these positions. The GAO report took

issue with the long education periods, some extending to 3 years. Also the GAO noted that equivalent positions in the Services were judged inconsistently regarding the need for graduate education. Some positions required advanced education and others did not. Positions were validated as requiring advanced education only because the officer in the position had an advanced degree. Official job descriptions requiring advanced degrees were submitted for validation which did not address the requirement for graduate education in the job descriptions. The GAO found from its sample audit of military installations that officers with graduate education were not being assigned to the positions which required graduate education.

The GAO recommended that the Services use short courses and work experience as alternatives to full-time graduate education. Also they should fill the positions with civilians where possible. DOD was requested to issue a new policy restricting the number of positions requiring a graduate education. Congress was requested to control the number of military officers in full-time, fully-funded graduate study by limiting the funds available.

DOD had encouraged the graduate education of military officers. In our society there are generally accepted values and benefits of graduate education. DOD felt that the graduate education enhanced the effectiveness and capability of the officers and was an important factor in retaining them.

The GAO considered the effectiveness of long-term, full-time graduate education for DOD civilians in non-government institutions [Ref. 28]. Long term training was considered training greater than 120 days. The training was through courses at the graduate level primarily in management, scientific, engineering, or technical fields.

The DOD installations were critized because they did not follow existing regulations. The field activities had not determined what their near and long term (5 year) training needs were nor had they prioritized them. The GAO found little evidence that there was a plan to use the new skills of the employee upon return from long-term training. In addition, the field activities had: a) not given much thought to selecting employees for training in areas where there was the greatest need; (b) overemphasized the requirement to obtain an academic degree; (c) not used any criteria for selecting non-government schools; and (d) not provided for any evaluation of the training to determine if its objectives were met.

The objectives of DOD's support of long-term, full-time training and education for civilian employees are as follows: (a) to maintain a position of leadership in defense-oriented science and technology; (b) to provide opportunities for career employees of promise to grow and realize their full potential; and (c) to better enable employees to successfully cope with the complex problems of managing all aspects of national defense activities.

The Civil Service Commission, DOD, and the Service's regulations emphasize that training qualify personnel for performance of official duties. The accomplishment of an advanced degree should be an incidental by-product of the training. The GAO found, however, the field activities' applications for long-term training implied that the individual was expected to achieve an advanced degree. Training programs were frequently structured so that they lead to an advanced degree, hence improving the prestige and image of the activity. Additionally, GAO found that the individuals applying for long-term training did so out of self-interest and their self-development did not support the training objective of the activity. The individuals selected their own course of study and selected the training institution.

The National Academy of Public Administration conducted a study on military officer graduate education in 1975 [Ref. 29]. This was just prior to congressional action on an OMB recommended 70 per cent reduction in funding for full-time, fully-funded graduate education. The panel concurred that the military should have educational background comparable with their counterparts in the private sector and government.

The existing system of counting positions requiring graduate education, however, should be replaced with one that sets educational standards and integrates the need with technical, organizational, and strategic plans. It recommended the Services utilize other programs such as off-duty, recruitment

of officers with advanced degrees -- especially in fields with shortages -- and cooperative study (flexibility for officers to take courses during normal working hours). The Navy and Air Force postgraduate schools were encouraged to increase their number of off-campus personal study courses so as to reduce the time in residency to complete graduate programs. In order to accomplish more off-campus education with high standards and quality, representatives of the Services and higher education should establish ground rules for instructor selection and credit transfer. The report emphasized the need for classroom situations with both civilian and military participation in the learning process.

The report noted that the need for graduate education is obvious in the physical, mathematical, and engineering sciences. These disciplines are used in the development and operation of high technology weapons, transportation, and communication systems. In addition, advanced education is necessary in biological, social, operational, and managerial services in order to manage, deploy, and operate these systems. Although the Services depend on civilian industry to provide the talent to produce the weapons they need, an officer corp less educated than its counterparts will be severely handicapped in its relations with civilians.

In a situation of reduced funding, technical advanced education is the beneficiary of a majority of the funds for full-time, fully-funded education. It is nearly impossible

for an officer to acquire an advanced degree in engineering or science through an off-duty or a partially-funded program; and it is easier to couple specific technical and science degrees with validated billets.

C. AFTER WORKING HOURS

The proliferation of after hours graduate programs has raised questions about the quality of these programs. Most installations have taken the view that having some graduate program offerings is better than nothing. These programs stretch out for several years and have high student drop-out rates. A majority of the programs are management vice technical oriented because most engineering schools have been reluctant to offer complete off-campus graduate programs.

There are some limitations to graduate education conducted under these conditions. Most employees/students are at a low point in their learning capacity and retention capability after a day's work. The employee's class attendance is frequently interrupted by work-related travel or problems. The classes consist primarily of work associates; therefore, there is not the opportunity to experience the multiple viewpoints occurring in the campus environment. Specific programs are difficult to sustain due to employee turnover, lack of recognition of credit for the courses by other higher education institutions, changes in the individual's education

goals, and declining interest in the specific programs offered.

The issue of "cheap degrees" offered at military bases was addressed by Gene Sherron, an American Council on Education Fellow [Ref. 30]. He indicates that most of the programs are so poor that these programs would be classed as diploma mills if given close scrutiny by the educational community. At least 19 colleges and universities from as far away as California offer graduate degree programs in Washington, D.C. Some major institutions refuse to participate because it is their position that quality graduate education belongs on campus where students have access to full time professors and research facilities.

So far the accrediting bodies and associations of higher education have not forced a policing or correction in the proliferation of advanced degrees around the nation. The declining enrollments and reduced college budgets have accelerated many institutions' quest for the available education dollars in the after-work-hours market. The DOD is partially to blame for allowing these institutions to offer their educational wares at military installations without any control of quality or admissions criteria. The local government administrator normally does not have an advanced degree and is under intense pressure to keep enrollments up and expenses down. Most programs use part-time instructors recruited locally.

D. THE CURRICULUM PROPOSALS

1. Naval Postgraduate School Informal Proposals

In the past seven years the NPS faculty have held informal discussions with T&E field activity representatives regarding the design of a T&E curriculum. Although it would be desirable to have a six quarter program, field activity management is strongly opposed to providing full-time training for more than one year. The military probably would not have difficulty with this point, since most of the sponsored NPS curricula are six quarters and longer. Table I summarizes informal NPS past proposals for a T&E curriculum. These proposals have a high probability and statistics content and a strong operations research orientation. The thesis requirement creates a heavy workload for the four quarter curriculum. Since the students most probably will have written technical reports prior to attending the NPS and will write technical reports upon return to their work place, the thesis requirement could be waived without reducing the quality of the graduate education. The NPS retains the control of the quality of the graduate education via having the student in full time residence at NPS; and the test activity would reinforce the quality of the educational experience through ensuring that the graduate has the opportunity to write a formal technical report upon completion of the NPS academics.

TABLE I

T&E 4 AND 6 QUARTER CURRICULA

Quarter	1	2	3	4	5	6
Probability	Probability	[Probability & Statistics (Q-1)]	[Statistics (Q-2)]	[Analysis of Data (Q-3)]	[Design of Experiments (Q-4)]	[Elective (Q-3)]
Matrix Algebra		[I* to Opera- tions Research (Q-1)]	[System Simulation (Q-2)]	[I* to Quality Assurance (Q-2)]	[T&E Case Study (Q-4)]	[Thesis (Q-4)]
[I* to Systems Engineering (Q-1)]		Test Planning	[Reliability (Q-2)]	[Maintain- ability (Q-3)]	[Thesis (Q-3)]	Thesis
Project Management		Test Instru- mentation	Human Factor Engineering	[Technology Update (Q-1)]	[Technology Update (Q-2)]	[Elective (Q-4)]
FORTAN ⁺ Programming (Q-1)						

NOTE: * - Introduction

+ - If no previous programming experience

[] - Indicates 4-quarter curriculum

(Q-1,2,3,or 4) Indicates quarter taken in for a 4-quarter curriculum. Reliability and Introduction to Quality Assurance would be combined in 4-quarter curriculum.

The NPS "strawman" curricula are informal proposals and do not really address responsibility for the program. In order to ensure that there is a linking of engineering, management, and operations research disciplines, some thought should be given by the NPS administration to considering this curriculum as a Masters of Science in Engineering-Management degree program. Although there appears to be adequate field activity interest in a T&E oriented curriculum at NPS, it has not happened for numerous reasons. Among these is a lack of high level Department of the Navy interest in a T&E program and the availability of the resources required by NPS to implement the program.

2. Pacific Missile Test Center

The Pacific Missile Test Center (PMTC) Point Mugu, California has advocated the establishment of an advanced degree in T&E since the mid 1970's. In 1974 it was able to establish an innovative, off-campus graduate education program in engineering with the cooperation of the California State University, Northridge [Ref. 31,32]. This program, Technical Professional Program, was developed around the new engineering graduate employee by PMTC.

The objectives were to prepare the engineer for roles as a technical specialist in T&E and to develop the engineer's skill and competence to plan and analyze large scale tests. The students attended classes half-time and worked half-time. They were expected to complete the program in one calendar year. The work projects were designed to support the

classroom studies. Certainly, this was a bold attempt to bring graduate education into the real world to support the needs of the practioner. Some of the weak points of this program appear to be the employee counselor, and a work dossier which was maintained by the student and graded as satisfying course requirements. This program placed much responsibility on the PMTC employees to act as pseudo-educators and to ensure that the students had project experience equivalent to an on-campus graduate level learning situation. The Technical Professional Program was conducted for one year ending in 1976.

The PMTC has drawn from the experience gained from the Technical Professional Program and has proposed the Test and Evaluation Intern Program [Ref. 33]. This is a two year program designed to develop a T&E Professional Engineer. Academic instruction is provided by California State University, Northridge and University of California, Santa Barbara. The program participants would spend the six semesters of the program at various test sites performing assignments in T&E of components, subsystems, and systems. Formal course work would be attended during part of the work day. The courses are listed in Table II. This program requires substantial support from the Navy T&E community to progress. It is a commendable effort because it, like the predecessor program, Technical Professional

TABLE II

PMTc T&E INTERN PROGRAM

Semester	1	2	3	4	5	6
	Principles of Navy T&E	Engineering Systems	Systems Engine- ering & Opera- tions Research	Alternate T&E Site Orienta- tion	T&E of X*	Final Report
	Management of Navy RDT&E	Design of Experiments	Information & Data Handling		Elective	Elective
		T&E Work Assignment (Components)	T&E Work Assignment (Subsystems)		T&E Work Assignment (System)	

NOTE: * - Aircraft, or Missiles, or Ship, or Software, or Component

Program, requires close working cooperation between the educational institution, the student, and the participating T&E activity to enrich the learning experience of graduate education.

E. CHARACTERISTICS OF PROFESSIONS

DOD high level officials have been reluctant to acknowledge the existence of T&E as being a distinct technical discipline. This is understandable because most DOD personnel are not familiar with the T&E process and its role in the acquisition of weapon systems. The President's Blue Ribbon Panel Report on OT&E supports this observation [Ref. 34]. Government personnel, primarily in the development test activities, have been the primary spokesmen for calling attention to the evolution of a T&E engineering discipline. Although they have asked academia to develop formal courses and curriculum to support their needs, engineering institutions have paid little attention to the requests of the T&E community. A review of the characteristics of professions is in order to help explain the lack of recognition of T&E as an engineering discipline.

The difference between occupations and professions can be viewed as a continuum. The occupations, such as carpentry and brick-laying, are on the lower end and medicine and law on the upper end of the continuum. A number of attributes have been defined which are normally associated with a profession

[Ref. 35]. These are: (1) a systematic body of theory; (2) professional authority; (3) sanctions by the community; (4) a regulative code of ethics; and (5) a professional culture. The U. S. Census Bureau in its occupational classification includes engineers in the professional category. Again, looking at the continuum of professions, the engineering profession would be considered below the law and medical professions. The environment in which most engineers work differs from other professionals [Ref. 25]. The T&E engineers, for example, differ as follows: (1) they do not choose their clients; (2) they do not have on the job autonomy; (3) they do not have to obtain a recognized postgraduate educational certification; and (5) they do not have a strong, professionally-backed set of standards and ethics.

The profession which has really arrived is noted by certain characteristics which enables it to exercise social control over its community. What evolves then is the professional community within the larger social community [Ref. 35]. The professional community members tend to take on the following characteristics: (1) bound by sense of identity; (2) once in the profession, continue for their whole career; (3) share values in common; (4) role definitions which are agreed to by both members and non-members; and (5) take on a common language which is only partially understood by non-members. In addition the community has power over its members; its imposed social limits are reasonably clear; and it controls the composition

of the community in the future through selection of professional trainees and the training processes. The T&E community has not demonstrated that it has moved to the point where it exhibits any of these characteristics.

The knowledge explosion has created specialization within the professions. Technology appears to be increasing almost exponentially creating a broad technical base and many combinations of knowledge. Professional specialization is partly responsible for creating the technology expansion which in turn has increased the amount of specialization. The specialist, for example the electronics engineer, may become obsolete because his specialty may still change too fast for an individual to keep current. His specialty might be superseded by advances in knowledge that make his knowledge or skill unnecessary or inadequate. To an increasing degree a professional career must be regarded as a continuous learning experience. The call by the DOD T&E community, for recognition as a unique engineering specialty, is an expression of this phenomenon.

F. FOCAL POINT FOR T&E EDUCATION?

The DOD sponsors the Defense Systems Management College (DSMC), Fort Belvoir, Virginia to train prospective program managers. The DSMC primarily provides training to military and civilian employees of the DOD who will be employed in the acquisition of weapon systems. There is also limited participation by contractors. The DSMC, therefore, has become a focal

point for the discussion, dissemination, and training in program management principles. Problems with the DOD acquisition cycle are aired here and possible solutions are discussed in a classroom environment. Students are instructed in problems and future trends in program management.

High level DOD management officials participate in DSMC sponsored programs and publications. Thus, through this focal point improvements in DOD management techniques can be proposed, assessed, and discussed openly. The resulting benefits to DOD, by providing program management training to military, civilian and contractor personnel are: (1) provides a common ground to communicate the DOD policy on acquisition management techniques; (2) prepares high level military and civilian personnel who will be assigned to program offices for the rigors of program management; (3) introduces these personnel to the political aspects of the acquisition of weapon systems; and (4) sharing of lessons learned from case studies of previous acquisition programs.

The T&E community has no counterpart to the DSMC. T&E has not been institutionalized in DOD. There is no recognized focal point in the T&E community where the Services can exchange lessons learned, share methodologies and techniques, build a knowledge base, disseminate information, conduct research, and encourage cooperation. With minimal interference from DOD each of the Services have developed separate approaches to T&E. The Joint Logistics Commanders work to improve

the participation of each of the Services in joint service acquisition programs. Ad hoc working groups are formed to study specific problems and to improve the conduct of joint Service programs. The Range Commanders Council, chaired by the Director of Defense T&E, occasionally sponsors ad hoc working groups to address T&E issues. Only the T&E activities designated as part of the Major Range and Test Facility Base (MRTFB) participate in this forum. They are listed in Appendix A, Table I.

The DOD through the DDT&E should sponsor a study or task the Services to compile the available knowledge on T&E. It should inventory the military and civilian skills required to conduct T&E.

G. TAILORING T&E EDUCATION

There is increasing evidence that greater cooperation between academic institutions and the worksite for graduate education can enrich the learning experience for all the participants [Refs. 33,37]. Academia receives immediate feedback for an evaluation of the curriculum and the needs of the student relative to the marketplace. The T&E education needs are a variable as shown in Figure 1. The more senior the DOD official involved in T&E the less are his T&E education requirements; and, therefore, T&E seminars of a few days would be appropriate.

The new engineer graduates have been high in analytical skills and low in synthesizing and design skills. The early

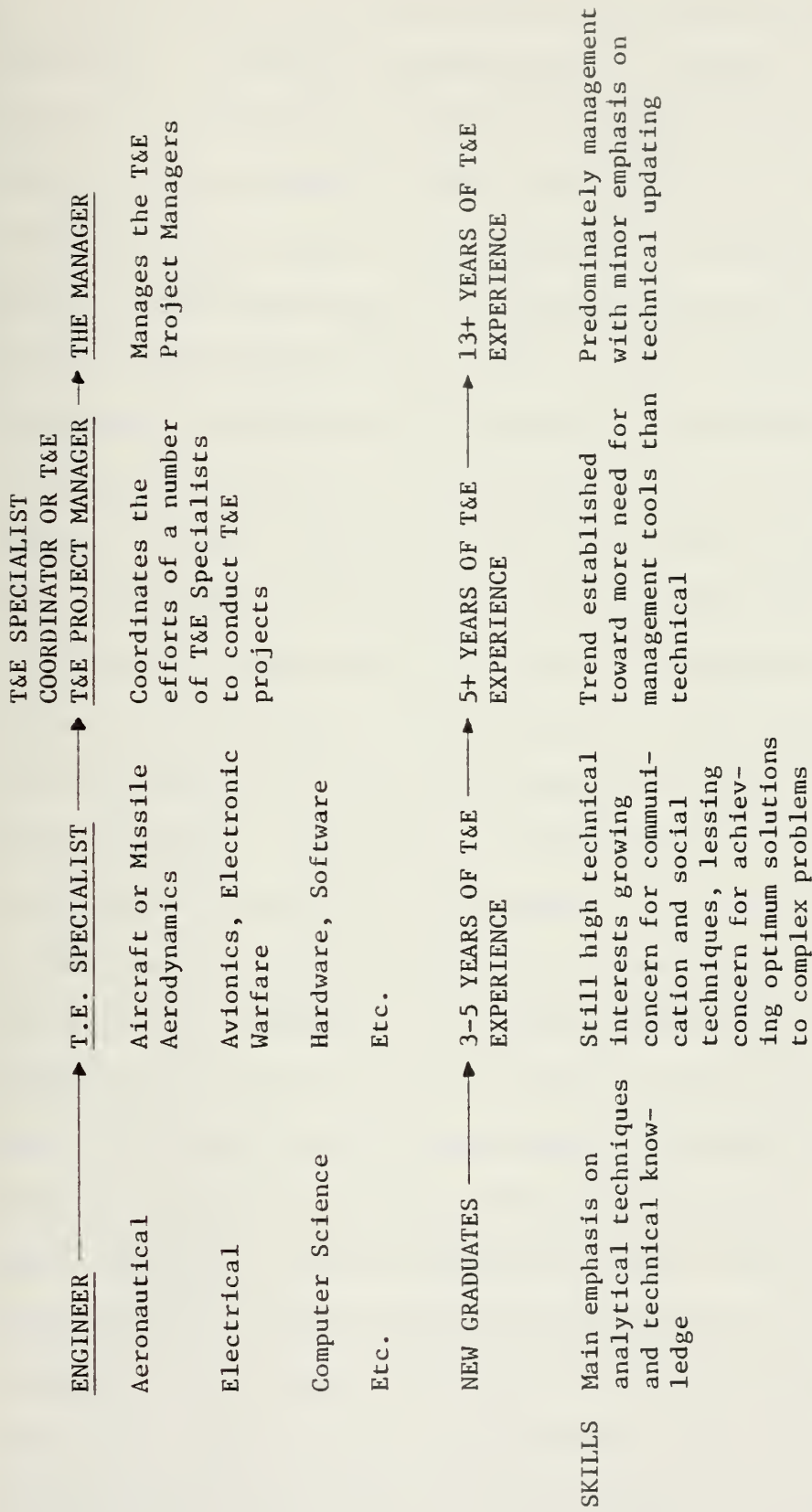


Figure 1. Evolution of T&E Education Needs

T&E experience is gained through assisting more experienced engineers. Through a combination of employer needs and the engineer's interests a degree of specialization evolves. The engineer, for example, after involvement in several test projects with a given type aircraft to determine its performance characteristics, may become aligned with one specialty of aerodynamics. He will then pursue technical updating in expectation of receiving a graduate degree. Most data shows engineers to be stable and 90% are expected to remain in their field for five years after graduation [Ref. 25]. Provided the engineer stays at a DOD T&E activity, he will observe that more of his time is occupied with management related matters. This situation also begins to surface the deficiencies in the engineering education for dealing with the social and human problems which are more difficult to bound than analytical problems. At this point a decision is required on pursuing technical management. Leaving the T&E activity, pursuing a technical specialist career or developing managerial skills are the main options available. Some T&E activities have been more successful than others in developing a dual career advancement program; however, this still remains a critical decision point for most engineers. The evolution of education needs as shown in Figure 1 gives evidence of the need for flexibility in the concept of T&E education. The needs of the specific T&E activity should be matched with the needs of the individual to perform his duties.

It is at this point T&E education can have a recognizeable form. The types of education which are shown in Figure 2 depict in general the needs of T&E personnel. The point at which these education needs change are peculiar to each individual and T&E activity. It does provide, however, an indication of the range of education required. The technical report writing and test planning need to be reinforced and integrated into the specific technical education courses. The repetition and reinforcement of these basic skills are critical in communicating T&E results concisely.

In the case of the military officer entering T&E of aircraft weapons systems a different education evolution occurs. The operating skills of the officer are used to support the T&E process. For example, it depends on which T&E activity he is assigned to as to whether or not he will receive specific training at the Naval Test Pilot School. This training develops the skills to conduct engineering flight testing. The military officer T&E education needs are normally different than those for the engineer. He may only spend two years in T&E and is more concerned with operating skills and management education. He may have already attended the Naval Postgraduate School and received graduate education in engineering prior to coming to the T&E activity. The officer who has a designated subspecialty as an aviation engineering duty officer normally has an advanced technical degree prior to coming to the T&E activity. His education

GRADUATE ENGINEER	T&E SPECIALIST	T&E SPECIALIST COORDINATOR	T&E MANAGER
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TECHNICAL TRAINING

Technical Report Writing
 Preparation of T&E Plans
 Specialized, e.g., U.S. Naval Test Pilot School
 On-the-Job Project Experience

TECHNICAL EDUCATION

Statistical Design
 Systems Engineering
 Instrumentation
 Technology, e.g., Electronic Warfare
 Computer Hardware and Software
 Analytical Techniques
 Engineering Discipline Electives, e.g. Electrical
 Emerging Engineering Disciplines *
 Technologies Unique to DOD

MANAGEMENT EDUCATION

T&E Case Studies
 Financial Decision Making
 Financial Management in DOD, e.g., Navy
 Project Management
 Operations Research
 Organizational Development
 Communications
 Acquisition Life Cycle of Weapon Systems
 T&E Management
 Budgeting, Planning, Programming Processes
 Policy Analysis

* e.g., Reliability and Maintainability

Figure 2. Education to Support T&E Specialists

needs would lie more to the right in Figures 1 and 2. If a T&E curriculum were available, for example at the NPS, then the officers completing the curriculum would be more effective at their jobs sooner and require less on-the-job training time. The officers interviewed in reference [2] indicated that knowledge about T&E principles and program management would have helped their effectiveness in their jobs and reduced their on-the-job training.

The need for T&E education so far has come from the personnel assigned to the T&E activities. The T&E body of knowledge is disbursed throughout the DOD T&E activities. The Director of Defense T&E (DDT&E) support is needed for the support of the activities' efforts to define their graduate education requirements. DDT&E could contract for a study with industry, a nongovernment academic institution, or a military postgraduate school on the issues involving T&E education. Some of the parameters this study could consider are: (1) the bounds and content of the T&E body of knowledge; (2) a focal point for T&E knowledge; (3) T&E education; (4) military careers in T&E; (5) future trends in T&E; and (6) rotation of civilian and military personnel between T&E activities.

The Congress has not always been pleased with the Services' management of T&E. Congress would be supportive of DDT&E efforts to exercise management improvement of the T&E process. Congress has expressed concerns in the past that the Service

filter T&E results of major weapon systems in order to enhance the chances Congress will provide funding for procurement. Various studies have critisized the delays, duplications, and cost of T&E. These are symptoms which have been treated by numerous directives and instructions and even establishment of the DDT&E. Possibly, through T&E education, developing a body of T&E knowledge, and establishing a DOD focal point for distribution of this knowledge the significance and role of T&E can be fairly assessed.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. General

The hypothesis is not presently supportable. There is little evidence to justify the establishment of a graduate T&E curriculum. There is a real need, however, for a compilation of the information available on T&E in the DOD. It is the DDT&E responsibility to define, support, and initiate this effort.

2. Specific

The DOD officials, in attempting to solve the problems of the acquisition of major weapon systems, identified weaknesses in the role of T&E. The solutions have been to change organizational structure and to change the timing and participation of T&E personnel in the acquisition cycle. The problems in T&E, however, seem more fundamental. The area of T&E education has not been considered by high level DOD officials as relevant to improving the effectiveness of T&E.

The Services have developed different implementations of the concept of independent testing as required by DOD directives. These differences raise policy, procedural and philosophical issues, when the Services are required to participate in joint-service acquisition programs. The same sort of situation also exists in combined intra-Service testing.

The trend for the future, in order to decrease duplication of efforts and acquisition costs and schedules, is to increase the number of joint-Service programs and of intra-Service combined tests. This points to a need for increased high level DOD officials' attention to the education and training needs of T&E personnel to reduce communication problems.

It is not generally accepted or recognized by high level DOD officials that T&E requires unique education. T&E in support of the acquisition cycle is, however, unique to DOD. The body of knowledge, professional society representation, and community characteristics do not exist in a highly visible form. The DOD T&E community is not well organized or well represented. There is no consensus on what a T&E specialist is. Most engineers and officers would not, if asked, claim to be a T&E specialist but would instead identify with the engineering discipline in which they earned their degree, for example electrical engineering.

Academic institutions have not generally embraced the concept of T&E as a specialty. There has been little academic interest in establishing T&E courses or developing faculty to support a T&E curriculum. The educational parameters necessary to support T&E seem to point more toward a blend of engineering and management education.

The T&E personnel are not very mobile. There has been very little effort in DOD to utilize T&E personnel across Service lines or intra-Service between test agencies. The

opportunities, therefore, for cross-pollenization of T&E skills, policies, test methods and lessons learned have been minimal. Government personnel policies do not provide for the transfer of T&E personnel to programs where their talents are most needed. The evolution and identity of the T&E Specialists with special education requirements can only be impeded by this policy.

The Naval Aviation Executive Institute (NAEI) program in cooperation with the Naval Postgraduate School could be the leader in the DOD for defining and supporting the graduate education needs of T&E personnel. Increased cooperation and flexibility are required between the NAEI, NPS, and the Navy's T&E agencies. The uncertainties, of future civilian T&E personnel participation in NPS provided education, could be resolved through improved communications of the needs of each of the participating organizations.

B. RECOMMENDATIONS

1. The Director Defense T&E (DDT&E)

The DDT&E should:

- (1) establish a focal point for the compilation and dissemination of T&E information.
- (2) initiate a study to define the DOD T&E body of knowledge.
- (3) sponsor an annual seminar on DOD T&E.

- (4) develop a seminar course consisting of 20-40 hours of instruction on DOD T&E for high level DOD officials.
- (5) assess the T&E related education needs of the T&E agencies and prepare a plan to support these needs.

2. The Services

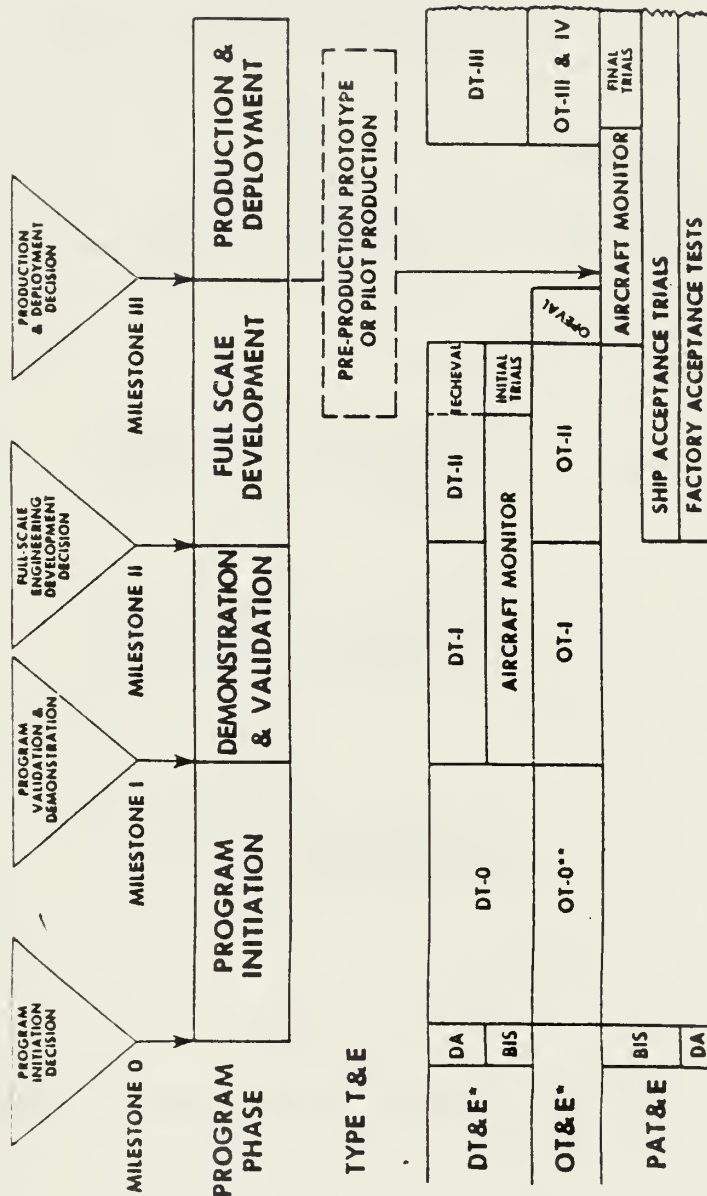
Each of the Services should:

- (1) compile its existing body of T&E knowledge.
- (2) review the educational needs of its T&E personnel.
- (3) define career paths for T&E personnel which includes involvement in acquisition management decision making.

3. NPS, NAEI, and the Navy's RDT&E Agencies

Representatives from these activities should meet to review the trends in graduate education, and the need to involve the NPS more closely in the integration of education with the education needs of the T&E practioners.

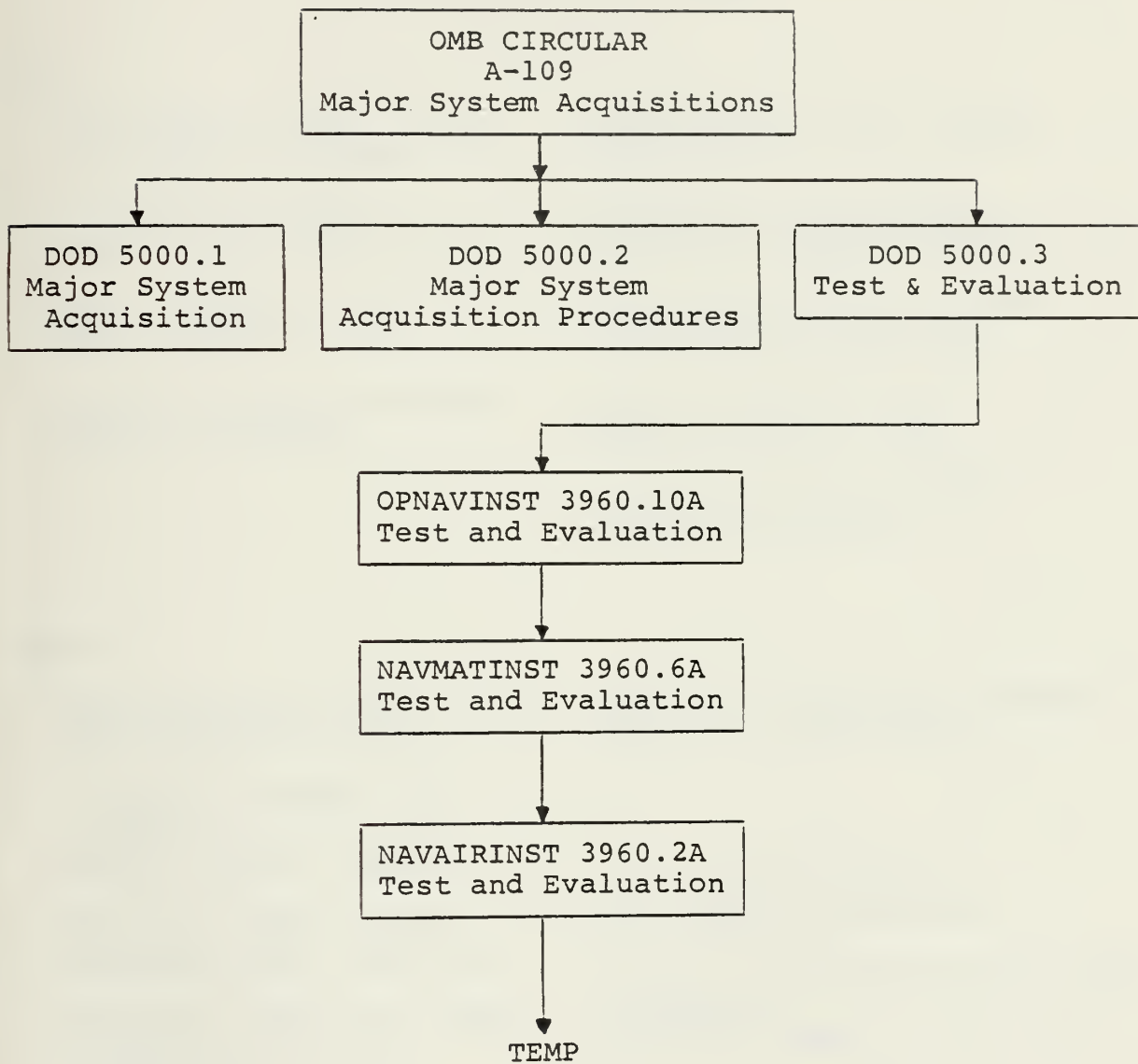
APPENDIX A



Source: OPNAVINST 3960.10A

Figure 1. T&E Phases

APPENDIX A



(Test and Evaluation Master Plan)

Figure 2. The Flow of Instructions to Develop a TEMP.

APPENDIX A

TABLE I

DEPARTMENT OF DEFENSE MAJOR RANGE AND TEST FACILITY BASES

ARMY

Cold Regions Test Center Fort Greely, Alaska	White Sands Missile Range New Mexico
Tropic Test Center Fort Clayton, Canal Zone	Kwajalein Missile Range Marshall Islands, Pacific
Yuma Proving Ground Yuma, Arizona	Electronic Proving Ground Fort Huachuca, Arizona
Jefferson Proving Ground Madison, Indiana	Dugway Proving Ground Salt Lake City, Utah
	Aberdeen Proving Ground Aberdeen, Maryland

NAVY

Pacific Missile Test Center Point Mugu, California	Naval Air Engineering Center Lakehurst, New Jersey
Atlantic Undersea T&E Center Andros Island, Bahamas	
Naval Air Test Center Patuxent River, Maryland	Naval Weapons Center China Lake, California
Naval Air Propulsion Test Center Trenton, New Jersey	Atlantic Fleet Weapons Training Facility Roosevelt Roads, Puerto Rico

AIR FORCE

Space & Missile Test Center Vandenberg AFB, California	Flight Test Center Edwards AFB, California
Eastern Test Range Patrick AFB, Florida	Armament Development & Test Center Eglin AFB, Florida

AIR FORCE (Continued)

Satellite Control Facility
Sunnyvale, California

Tactical Fighter Weapons
Center
Nellis AFB, Nevada

Air Defense Weapons Center
Tyndall AFB, Florida

Arnold Engineering Development
Center
Tullahoma, Tennessee

4950th Test Wing
Wright-Patterson AFB, Ohio

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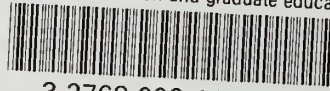
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